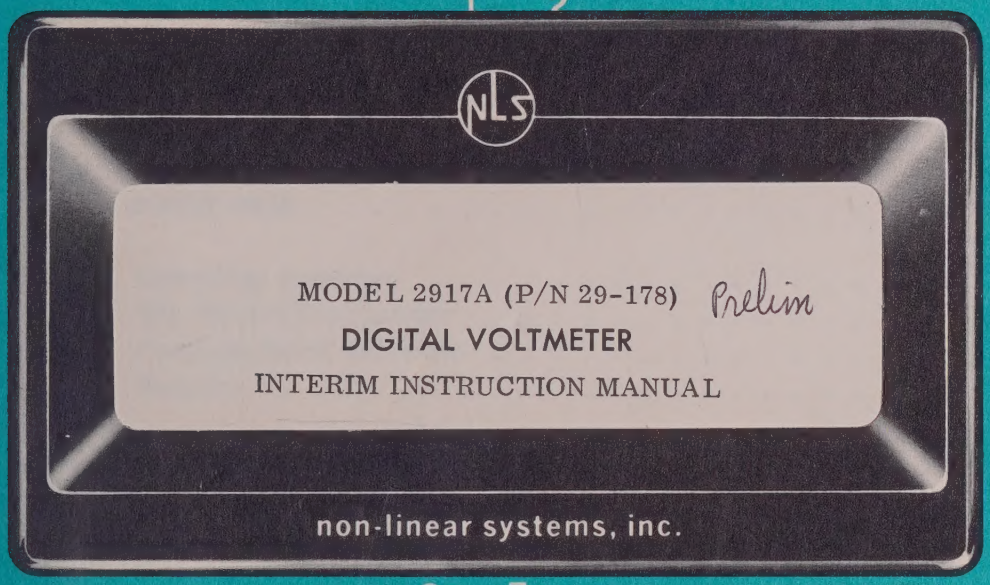

MODEL 2917A (P/N 29-178) Prelim

DIGITAL VOLTMETER

INTERIM INSTRUCTION MANUAL

non-linear systems, inc.

non | linear

systems, inc.

DEL MAR, CALIFORNIA

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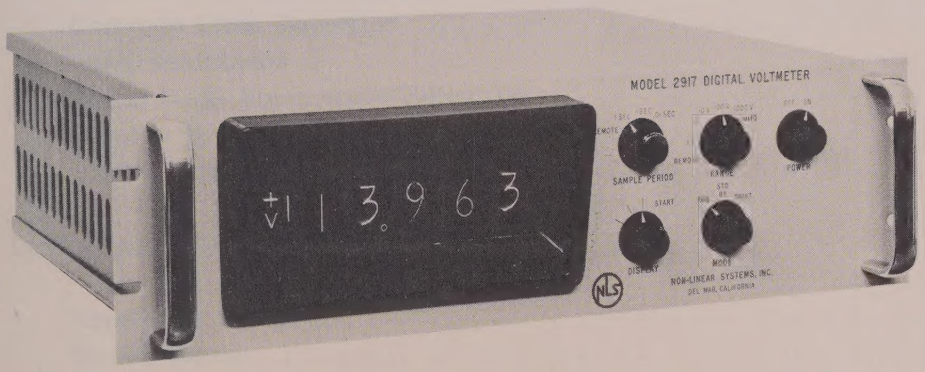

Originator of the Digital Voltmeter
non-linear systems, inc.
DEL MAR , CALIFORNIA

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CHAPTER I

INTRODUCTION

The NLS 2917A (P/N 29-178) Digital Voltmeters are solid state integrating instruments which measure the absolute value of DC voltages or the true integral of varying voltages. In these instruments the unknown input voltage is converted to a pulse train whose repetition rate is directly proportional to the input voltage magnitude. The total number of pulses generated over an accurately clocked one-second interval is counted electronically and displayed as the voltage value.

OPERATING PRINCIPLE

In a typical instrument, an input of 100 millivolts creates 100,000 pulses in one second; this is displayed as 100.000 MV. If the input voltages change during the measuring interval, the pulse repetition rate changes proportionately, and the total number of pulses that occurs during the one-second sample period is a measure of the number of volt-seconds at the input. Since these instruments mathematically integrate the input voltage, they are useful for obtaining the velocity from a voltage which is proportional to acceleration. In addition, these instruments are inherently able to reject sinusoidal ripple because the integrated value of an integral number of sine waves is zero. Therefore if an integral number of cycles of sine wave noise occurs during the one-second sampling interval, its contribution to the over-all reading is "integrated out." It should be noted that with a 0.01 second sampling rate there is not time for an entire 60-cycle sine wave and some measurement inaccuracy would occur; however at the instrument's slower sampling rates, the error is reduced to negligible value. With sine wave noise of 400 cycles, high reading accuracy can be maintained even with a 0.01 second sampling rate.

THE REVERSIBLE COUNTER

The NLS Model 2917A instruments are uniquely able to provide a higher order of accuracy than that available with other integrating type digital voltmeters because the NLS instruments have a reversible counter. It is only with this type of circuit that an integrating instrument can render a true average reading, for without a reversible counter, any AC component imposed upon the DC input will cause a zero-crossing error which accumulates each time the AC component causes the amplifier output to cross the zero level. More detailed information about this characteristic is contained in the Appendix.

COMMON MODE REJECTION

As shown in the Specifications, Chapter II, the common mode rejection capability of a 2900 Series instrument is extremely high. For the most part, this is due to the use of

photoelectric coupling devices which avoid the need for electrical connection at the converter output and at the range command signal connection to the converter.

STABILITY

Long-term stability and reliability are assured in part because no vacuum tubes are used in this instrument. Therefore the problems associated with changing emission levels and with heating are eliminated. The whole instrument dissipates only about 25 watts and no blower is required. In fact, the problem of heat is so minimal that only a few heat sinks are used. Because of this cool operation, the instrument is not likely to require frequent recalibration.

CHAPTER II

SPECIFICATIONS
MODEL 2917A

FUNCTION: Voltage measurement.

RANGES: As indicated by the RANGE control on the front panel, the instrument has five ranges. However, the manner in which values in each range are displayed is affected by the sampling period selected. The following table illustrates the several combinations of sampling time with the RANGE control set in each of its positions; in addition, the maximum over-range figures for each setting are given.

SAMPLE	RANGE CONTROL SETTING	FULL-SCALE READING	MAX. OVER-RANGE READING FOR RATED ACCURACY
1 Second	0.1 V	99.999 MV	120.000 MV
	1.0 V	.99999 V	1.20000 V
	10 V	9.9999 V	12.0000 V
	100 V	99.999 V	120.000 V
	1000 V	999.99 V	1200.00 V
0.1 Second	0.1 V	.09999 V	0.12000 V
	1.0 V	0.9999 V	01.2000 V
	10 V	09.999 V	012.000 V
	100 V	099.99 V	0120.00 V
	1000 V	0999.9 V	01200.0 V
0.01 Second	0.1 V	0.0999 V	00.1200 V
	1.0 V	00.999 V	001.200 V
	10 V	009.00 V	0012.00 V
	100 V	0099.9 V	00120.0 V
	1000 V	00999. V	001200. V

ACCURACY: On the 0.1V range.

Accuracy at 25°C: ±0.02% Rdg. ±0.01% F.S. ±2 digits. Temperature effects: ±0.002% Rdg. per °C ±0.003% F.S. per °C.

On the 1, 10, 100, 1000V ranges.

Accuracy at 25°C: ±0.01% Rdg. ±0.005% F.S. ±1 digit. Temperature effects: ±0.001% Rdg. per °C ±0.0005% F. S. per °C.

MEASUREMENT TIME: Sample period may be set at 0.01, or 0.1, or 1 second. As shown under Range, resolution decreases as speed increases. AUTO RANGE selection does not change the sample period; however, up to 50 MSEC per measurement may be added for RANGE selection.

MAXIMUM NUMBER OF MEASUREMENTS: 10 per second.

COMMON MODE REJECTION: 120 DB at 60 CPS
160 DB with DC

INPUT RESISTANCE: 100K ohms on 0.1 volt
1 megohm on 1 volt
10 megohms on all higher ranges

SIGNAL MODE INPUT NOISE REJECTION: The integrating characteristic inherently averages out signal noise. Noise rejection varies with noise frequencies and sample period. AC noise attenuation is infinite for 1, 2, 3, etc. CPS noise frequencies for a 1 second sample period; for 10, 20, 30, 40, etc. CPS for 0.1 second period; and for 100, 200, 300, etc. CPS for 0.01 second period. The following table gives minimum noise rejection ratings at various frequencies for the three sample periods:

SAMPLE PERIOD	NOISE FREQUENCY			
	CPS 60 - 100	CPS 100 - 200	CPS 200 - 500	CPS 500 - 1000
1 Second	42 - 46 DB	46 - 52 DB	52 - 60 DB	60 - 65 DB
0.1 Second	22 - 26 DB	26 - 32 DB	32 - 40 DB	40 - 46 DB
0.01 Second	2 DB	8 DB	15 DB	22 DB

NOTE

The values set forth in the preceding table apply ONLY if the instantaneous input voltage does not exceed 120% of full scale at any time during the sample period.

DISPLAY TIME: The readout display duration may be for 1/4, 1/2 or 2 seconds before another scan is started when MODE switch is in RUN position.

DIGITAL READOUT (PRINT): Decimal voltage level. Levels are 0 V for logic "1", -27 volt for Logic "0", 5 MA., maximum. For Output functions and Remote functions, see Drawing No. 29-178, Sheet 3.

CHAPTER III

INSTALLATION AND OPERATION

UNPACKING

Instruments are shipped in two-piece polystyrene-bead containers. Cut the tape between container halves and open. If damage is seen, promptly notify the carrier. There is no packing material inside of the instrument. It is suggested that the container be saved if the instrument is to be shipped at a later date.

POWER SOURCE

The instrument is ready for operation from conventional 115 volt, 60 cycle power sources. A 220 volt source may be used if the two primaries of the power transformer are wired in series instead of in parallel. Schematic drawing at end of manual identifies the windings.

FUSING

The instrument is protected by a 3 AG 0.6 ampere slo-blo fuse in an extractor post on the rear panel. Always use a fuse of the correct value.

POWER GROUNDING

The third pin on the power plug grounds the chassis of the instrument. The internal guard area is always isolated from ground. While general electrical practice required that a chassis ground be provided to avoid shock hazard, the power line ground, as such, is not related to the instrument's ability to provide accurate readings.

CABLES

The instrument is supplied with an input cable, Drawing No. 15004-126. The red pin is signal high; black is signal low; blue is guard shield. There is no connection to the chassis of the instrument. All inputs go directly inside of the guard shield area. When measuring a signal that should be shielded, the blue guard shield lead is used; at other times the black and blue leads may be tied together.

The instrument is furnished with mating connectors for printer operation and remote control. Connections to all cables are made at the rear of the instrument.

Refer to page 3-3 for cable fabrication information.

CONTROLS

POWER SWITCH

The POWER switch has two positions - ON and OFF. Although the instrument is ready to provide fairly accurate readings within 15 minutes, utmost accuracy is assured if a 30-minute warmup period is allowed.

SAMPLE PERIOD

This control is used to select the measurement time by internally determing the scanning rate of the instrument. When set at the REMOTE position, this function is controlled from a remote operation point connected to the instrument's remote cable. See schematic drawing for connection information.

RANGE

This control selects the range within which the input value falls. A certain amount of over-range is permissible (and a sixth digit will illuminate during over-range operation). See the Specifications, Chapter II, for specific range as related to each sample period. The REMOTE position on this control transfers this function to a remote operation point connected to the instrument's remote cable. The AUTO position is for full automatic ranging. See schematic drawings for connection information.

DISPLAY

This switch is used to select the readout display time before a new scan is initiated. The extreme counterclockwise position provides an image persistence of approximately 1/4 to 1/2 second; the next position provides about 1 second; the last position provides about 2 seconds. Added to this switch at the clockwise end of travel is a spring-return START position. This position is used when the instrument is in either STANDBY or in PRINT to initiate a new scan. The switch should be turned to this position for only a moment. The operation provided by this control is not available remotely.

MODE

One of the following three modes of operation may be selected:

RUN - At the end of display time, the instrument is internally started on a new scan and the instrument will continue to scan and display indefinitely.

STANDBY - After one scan the instrument will provide a display and stop operation until externally triggered to scan again, or until the display control is momentarily rotated to the START position.

PRINT - At the end of scan, the instrument will generate a negative 10-volt print pulse of 20-millisecond duration to operate a HP-562A printer. The instrument will only scan again when a print command is issued by the associated printer. See schematic drawings for connection information.

NOTE

The following information will be helpful in fabricating a cable to connect J1 of the DVM to J101 and J102 of the printer (See NLS Drawing No. 29-178, Sheet 3, Outline Drawing. and refer to HP562A Operating and Service Manual, page 1.2-4):

J1 OUTPUT FUNCTION	DESTINATION	J101 or J102
1	connects to	A Bit
2	connects to	B Bit
4	connects to	C Bit
8	connects to	D Bit
- Reference	connects to	- Reference
+ Reference	connects to	+ Reference
Print Start	connects to	- Print Command
DVM Start	connects to	- Inhibit
Ground	connects to	Ground

CHAPTER IV

THEORY OF OPERATION

GENERAL THEORY

In integrating digital voltmeter instruments the unknown input voltage is converted to a pulse train whose repetition rate is directly proportional to the input voltage magnitude. The total number of pulses generated over an accurately clocked 1 second interval is counted electronically and displayed as the voltage value.

In a typical instrument, an input of 100 millivolts would create 100,000 pulses in one second, and this would be displayed as 100.000 volts. If the input voltage changes during the measuring interval, the pulse repetition rate changes proportionately, and the total number of pulses that occur during the 1 second sample period is a measure of the number of volt-seconds at the input. Therefore, these instruments effectively mathematically integrate the input voltage. Thus, for example, they are useful for obtaining velocity from a voltage which is proportional to acceleration.

Another advantage of these instruments is their inherent ability to reject sinusoidal ripple. This ability stems from the integrating characteristic of the instrument, and the fact that the integrated value of an integral number of sine waves is zero. Therefore, if an integral number of sine wave noise occurs during the one-second sampling interval, their contribution to the over-all readout is "integrated out."* Sampling times of 1 second, 0.1 second and 0.01 second are usually supplied in integrating DVM's. At the 1 second and 0.1 second intervals, 60 cycle or 400 cycle noise would be virtually completely rejected. On the 0.01 second sampling period, an entire 60 cycle sine wave would not occur, and 60 cycle noise would produce some inaccuracy in measurement; however, 400 CPS noise would be rejected.

The basic functional diagrams of integrating DVM's are shown in figures 4-1 and 4-2. The unknown input voltage is applied to an integrating circuit whose output is a ramp function whose slope is proportional to input amplitude. This ramp is fed to a voltage comparator which will, at some accurately fixed voltage value, reset the integrator to zero volts instantaneously; whereafter the integrated output will again start climbing toward the voltage comparator's limit value. Thus, a sawtooth function is generated whose frequency is proportional to input voltage. Typically, such an integrator would produce an

* Integrating gives the time - average value of the input voltage in the same way that we obtain average velocity by dividing distance traveled in a given time by the elapsed time.

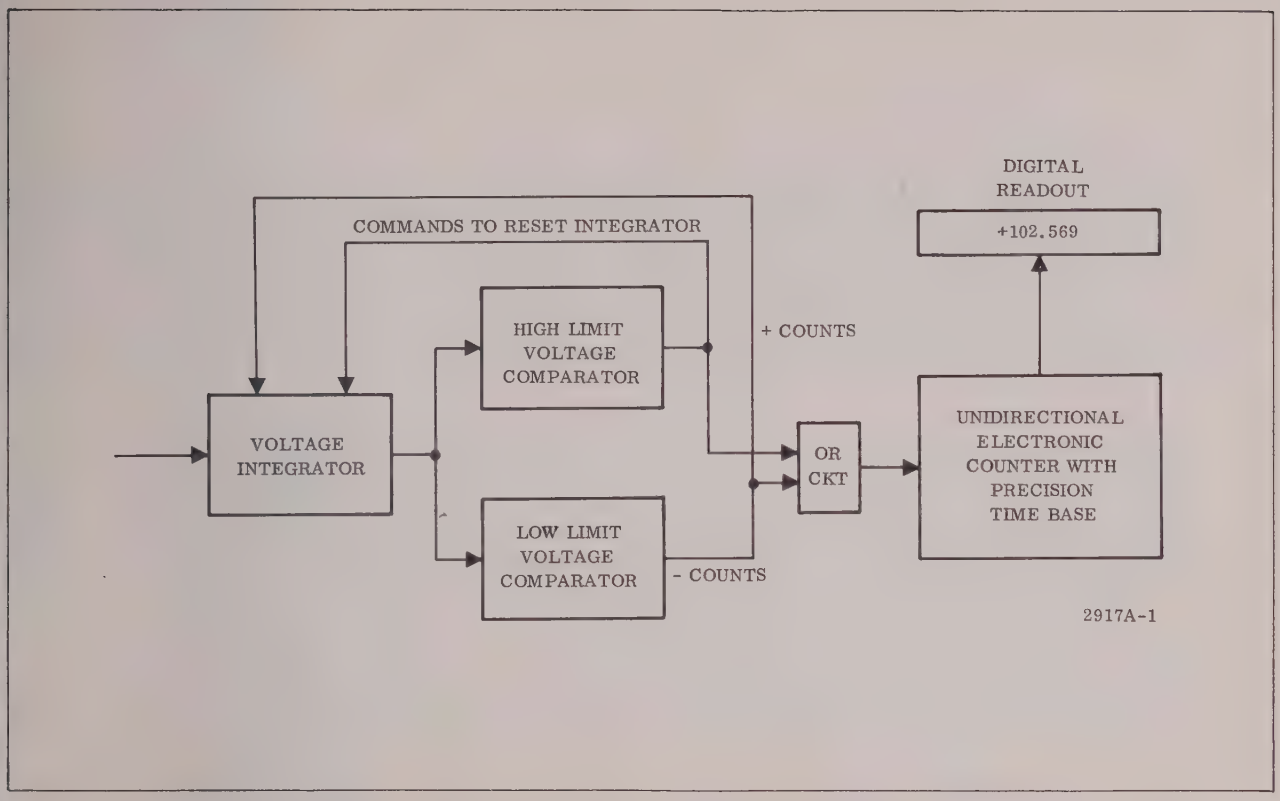

Figure 4-1. An Integrating DVM That Will Not Properly Evaluate or Integrate Inputs That Change Polarity During The Sample Period.

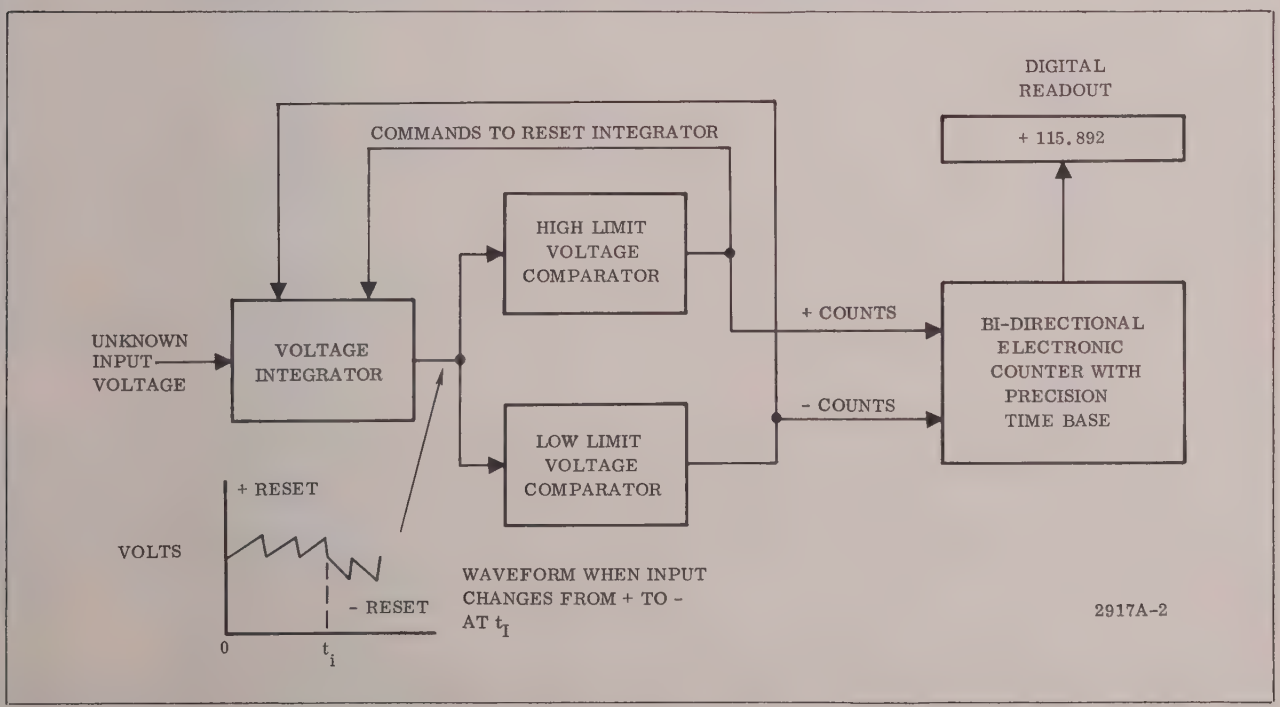

Figure 4-2. A Versatile NLS Integrating DVM With Bi-directional Counter to Properly Average or Integrate Inputs That Change Polarity During The Sample Period.

output which would reach the reset limit at the end of 1 second with a 1 microvolt input, and the lowest range of a digital voltmeter of this type would produce 1 count at the end of 1 second with 1 microvolt input. Full scale on this low range would be 99.999 millivolts, which would produce a frequency of 99,999 cycles per second. Some integrating DVM's use voltage controlled oscillators different than the one described above, but the over-all DVM principle is the same. Additional ranges are obtained by attenuating the input voltage in decade steps.

Although most integrating digital voltmeters available today are of the type shown in figure 4-1, they have serious difficulties which are eliminated by the bi-directional integrating DVM of the type built by Non-Linear Systems, Inc., and shown in figure 4-2. In figure 4-1 changing the input voltage polarity does not cause the counter to count backwards. Therefore, when using the instrument for mathematical integration, the integral of the absolute value of the input is displayed, without regard to sign. For example, if an AC sine wave is applied, the DVM of figure 4-1 reads twice the area under one-half the sine wave, whereas the Non-Linear Systems' bi-directional integrating DVM of figure 4-2 reads the true integrated value of the sine wave, which is zero (of course, the DVM of figure 4-2 could be modified to operate the same as the one in figure 4-1, if required). Another item to check in integrating DVM's is the necessity for periodic recalibration of the integrator reset circuits of figures 4-1 and 4-2. In some cases, the blocking oscillators used as resetters must be manually recalibrated from hour to hour against a built-in standard, to obtain full specified accuracy, while NLS integrating DVM's have intrinsically stable resetting circuits that do not require periodic adjustment. Furthermore, the polarity sign of the DVM in figure 4-1 will be the polarity that the input signal had at the instant the sampling period ended; even if the input signal was predominately positive, a negative sign is likely to be displayed in the readout (Figure 4-3). In the Non-Linear Systems' bi-directional DVM of figure 4-2 however, the bi-direction counter counts forward when the input signal polarity is positive and counts backwards for negative inputs. Thereby, it gives a true mathematical integral, and its polarity sign represents the true polarity of the input average value, even when the input voltage passes through the zero axis during measurement.

Some integrating DVM's have a zero crossing error which can cause several digits error each time the input waveform goes through zero volts. Therefore, if one is attempting to measure a small DC voltage which has enough sinusoidal ripple to cause voltage excursions through zero value (as in figure 4-3) large errors can occur, and such DVM's are therefore not accurate "null meters." The design of NLS integrating DVM's eliminate this zero crossing error.

An advantage of the integrating DVM which has heretofore been almost completely ignored is encountered when measuring varying voltages to which statistical analysis must later be applied. If such voltages are measured with a tracking logic or scan logic potentiometric DVM, the numerals obtained will be biased toward 9's (e.g., 1.119, 1.129 or

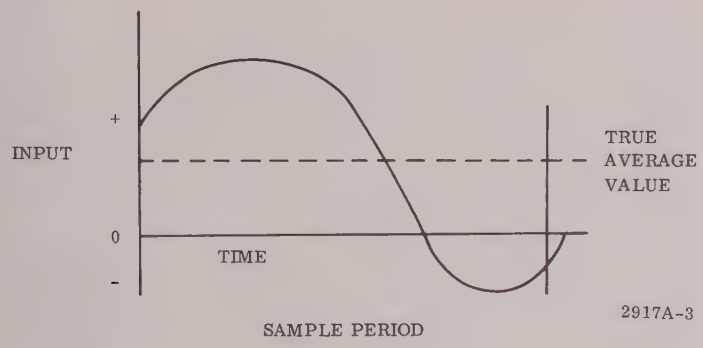

Figure 4-3. The DVM of figure 4-1 displays a - sign when reading the input shown here. Also, it adds the average value of the positive portion to the average value of the negative portion, thus giving a high reading. The NLS DVM of figure 4-2 gives the true average value.

1.199, 1.299, etc.) when increasing voltages are measured, and toward 0's for decreasing voltages. Integrating DVM's do not have this numerical bias.

SPECIFIC THEORY

Basically, the 2917A instrument consists of two functional units, the converter unit which changes the given input voltage to frequency, and a reversible counter which counts the converter frequency (See figure 4-4). There is no direct electrical connection between the converter and the counter units.

THE CONVERTER UNIT

The heart of the converter is a highly stable, wide band chopper-stabilized differential amplifier, often called a Miller Integrator. Connected as shown, the amplifier generates an output whose rate of rise is directly and linearly (0.01%) proportional to the input voltage. Two precision Schmitt triggers are connected to the output of the amplifier. One Schmitt trigger will fire at about 1.3 volts if the amplifier swings positively and the other will fire at 0.8 volt if the output voltage swings negatively. When the Schmitt trigger fires through the pulse-shaping network, a fixed amount of charge is delivered to the summing node of the amplifier to neutralize the input current. This action forces the summing node back to ground potential and the output of the amplifier is reset and another pulse is generated again. Since the slope (the rate of rise) of output voltage is linearly porportional to the input

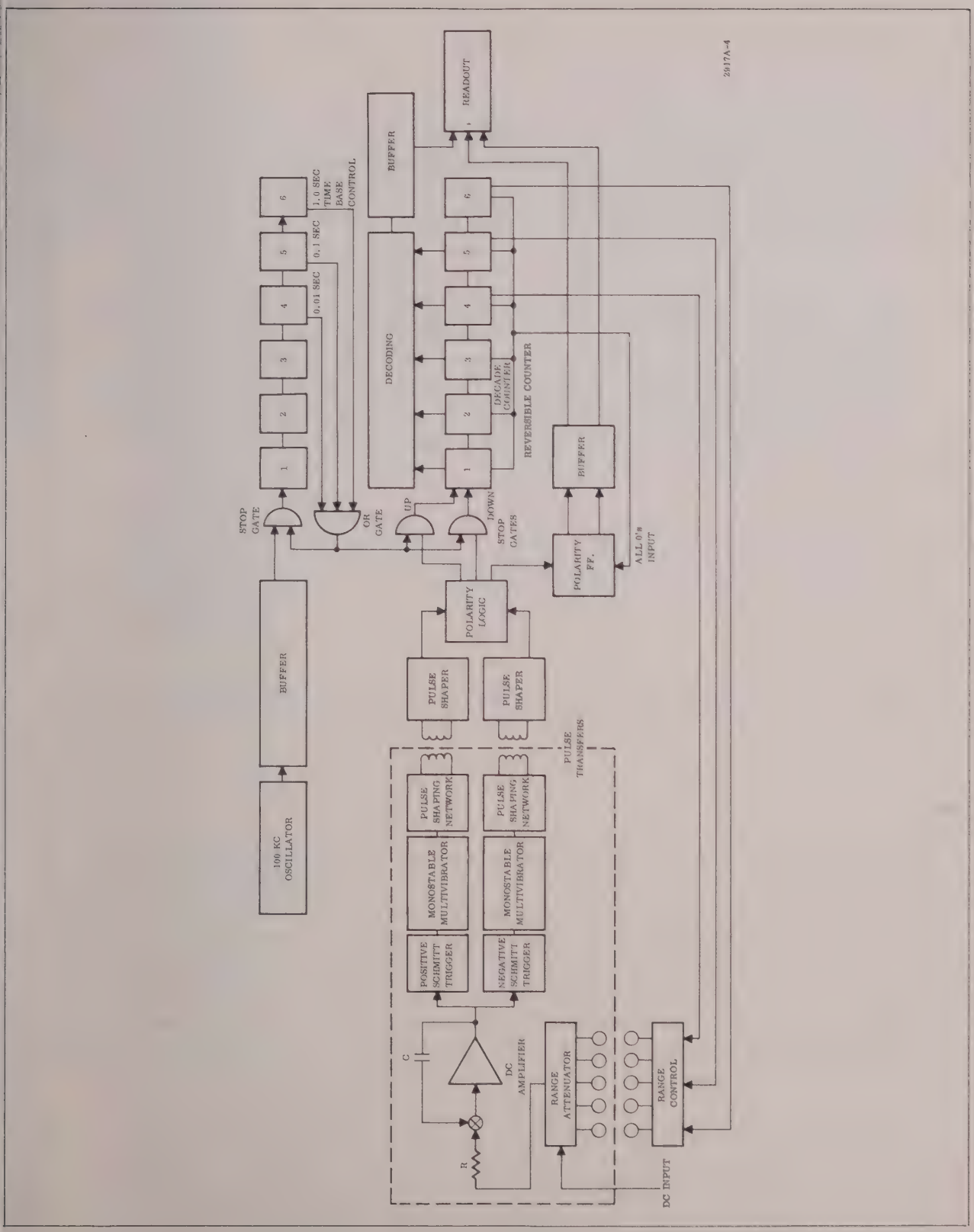

Figure 4-4. Functional Block Diagram.

oltage for a given time, the frequency at which the Schmitt trigger is fired is also directly roportional (0.01%) to the input voltage. Thus, DC voltage is converted to pulses whose ate of occurrence is an indication of the magnitude of the input voltage. If these pulses re counted, the number of pulses per unit time is an indirect measurement of the input oltage.

The monostables which follow the Schmitt triggers serve as buffer amplifiers. To rovide high common mode rejection, the output of the buffer amplifiers is fed into neon ulbs which emit light to activate photo cells (outside the converter box) whose outputs are sed to trigger the counter amplifier. The technique is used to actuate the relays in the at- enuator; this time, however, the control neon bulbs are located outside the converter and ne photo-conductive cells (that control reed relays) are inside the converter box.

THE COUNTER UNIT

The pulses transmitted to the photo cells are used to trigger the converter amplifiers. he counter then counts these amplified pulses whose numbers are indicated in the readout. lso, since the counter is reversible, the total count numerically represents the true in- egral of the input voltage.

From the foregoing description, it can be easily seen that the photoelectric coupling, lus the integrating property of the amplifier, lead to an extremely high common mode level f rejection.

IPPLE ERROR

One advantage of integrating DVM's is that, without using input filters, they completely eject sinusoidal AC ripple superimposed on the DC voltage being measured, provided that n integral number of noise cycles occur during the DVM's sample period. This is because he integrated value of a sine wave is zero. They'll also completely reject any ripple wave- orms other than sinusoidal if the area (volt seconds) of the positive polarity section of the ipple waveform is equal to the wave form's negative polarity area. The maximum measure- ment error caused by ripple occurs when the ripple frequency is such that instead of an in- egral number of cycles of ripple occurring during the DVM sampling period, an extra half ycle of ripple gets through (See figure 4-5).

This maximum error is calculated by determining how many volt seconds (area FEC n figure 4-5) the extra half cycle of ripple adds to the volt seconds created by the DC signal area ABCD in figure 4-5). The area FEC (in volt seconds) is the average ripple voltage RMS value $\div 1.11$) multiplied by one-half the ripple waveform period. Area ABCD is found y multiplying the DC amplitude by the DVM sample period. The % error is then 100 times he ratio of area FEC to ABCD or:

$$\% \text{ error} = \frac{\dfrac{\text{RMS ripple amplitude}}{1.11} \times \dfrac{\text{ripple period}}{2}}{\text{DC amplitude} \times \text{DVM sample period}} \times 100$$

Example: What error is caused by 0.3 volts RMS of 100.5 CPS sine wave ripple superimposed on a 20 volt DC signal, using a 1 second DVM sample period?

$$\% \text{ error} = \frac{\dfrac{.3}{1.11} \times \dfrac{1}{100.5 \times 2}}{20 \times 1} \times 100 = 0.00667\%$$

Thus, only 0.00667% error was caused by a ripple voltage whose peak value is 2.1% that of the DC voltage being measured. Note that this is an extreme case since ripple frequencies usually encountered are not odd values like 100.5 CPS, but are whole number values (50, 60, 400, or integral multiples of these), and ripple of such frequencies would be completely rejected.

Ripple-caused error decreases if DVM sampling period is increased, or if ripple frequency increases. For example, the error caused by a 0.3 V RMS 10.0005 KC ripple signal on a 20 VDC signal measured with a 1 second DVM sample period would be 0.000065% of reading.

If the ripple is so great as to cross the zero axis (figure 4-6), some integrating DVM's will add the negative area (area below zero axis) to the positive area, and will display the last polarity encountered (in this case, negative). This results in highly erroneous measurement, and makes the instrument virtually useless for measuring low voltages in the presence of noise. NLS integrating DVM's are unique in this regard, since they have a bi-directional counter and therefore give the true integral (subtracting the negative area from the positive) and give the correct polarity sign. Furthermore, NLS integrating DVM's do not accumulate one digit of zero crossing error each time the input crosses the zero axis.

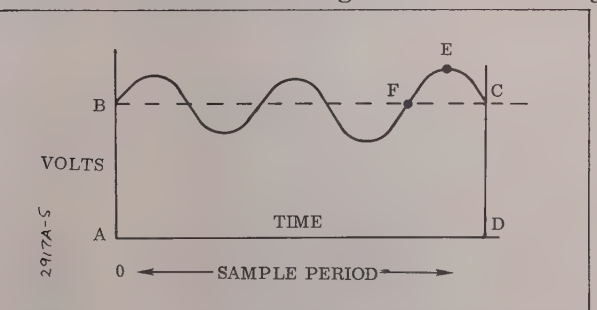

Figure 4-5 DC Signal with Superimposed Noise

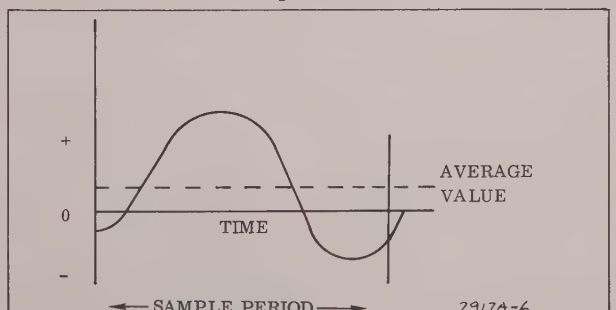

Figure 4-6 AC Noise Crossing the Zero Axis

CHAPTER V

CALIBRATION

When a 2917A instrument is not providing readings within specifications, it is time for calibration, repair, or both. In the calibration information given in this section, it is assumed that the instrument is in good working order. The physical location of the several adjustments is shown in Figure 5-1. Follow all steps in the sequence listed.

CALIBRATION EQUIPMENT NEEDED

EMF Standard, such as NLS Model 3006. This EMF Standard contains nine unsaturated cadmium standard cells connected in series, and provided with Superior Electric Five-way binding posts which are connected to each series junction to make available the voltage from each cell. The available voltages range from approximately 1.019 to 9.172. The Model 3006 is supplied with two calibration tables which indicate voltage values carried to six decimal places and accurate to 0.01%. One table gives the open circuit EMF; the other table gives the output voltage values for a 10 megohm load. In addition, the tables give the cumulative voltage of the cells such as 1.01914, 2.03843, 3.05764, . . . 9.17724. These cells have been calibrated at the NLS Standards Laboratory with an NBS certified primary reference.

Stable, but not necessarily precisely known DC sources of 0.08-0.1, 0.8-1, 8-10, 80-100, and 800-1000 volts. It is important that the top values for each voltage given not be exceeded; it is also necessary that a correct ratio, ±0.01%, exist among these voltages. These ratios can be readily obtained by the use of a ratio box such as the NLS Model 3020. This NLS ratio box provides rapid and convenient switching facilities for fast, accurate calibration of digital voltmeters.

A frequency counter which can count to 100 KC, accurate to ±1 part.

PROCEDURE

NOTE

Before calibrating the instrument, the frequency of the crystal oscillator should be checked and, if necessary, adjusted as follows:

Place board P-25-P-26 on an extension board and connect the counter input to P26-6. With a non-metallic screwdriver adjust the clock frequency to provide exactly 100,000 CPS.

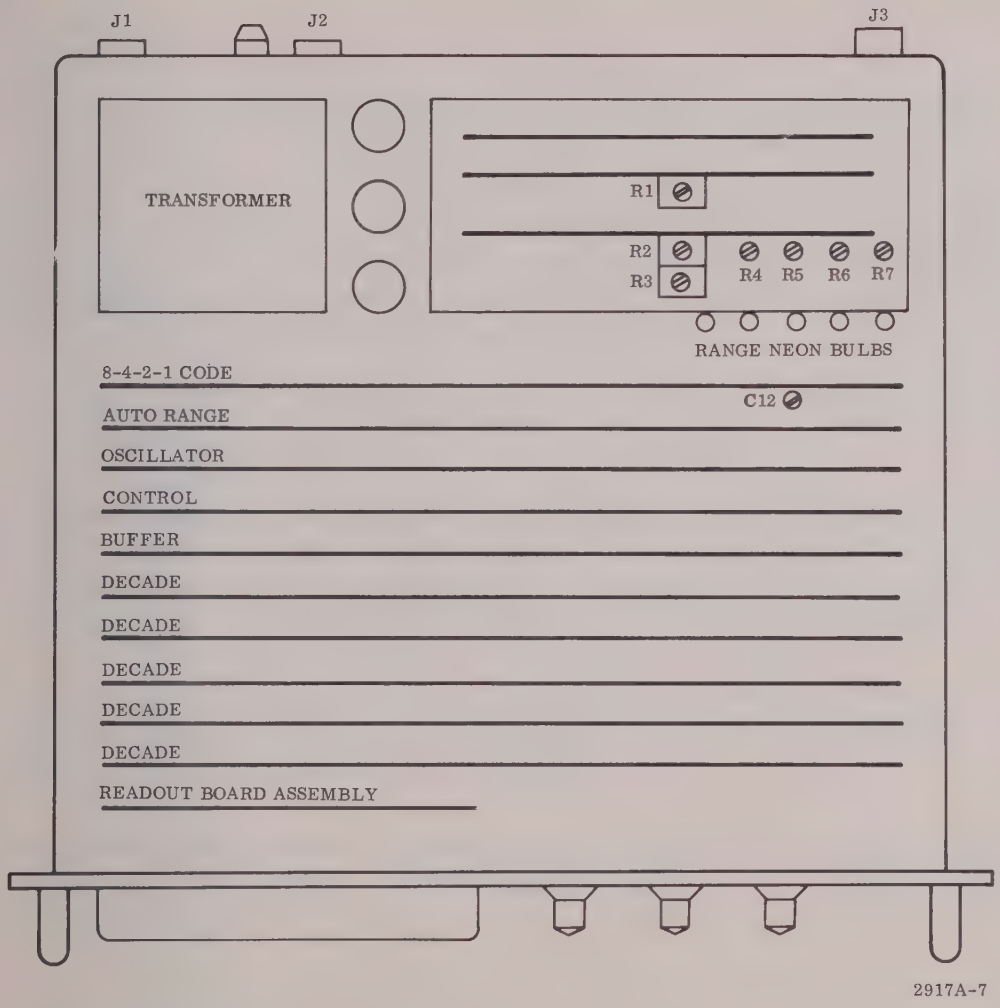

Figure 5-1. Top View of Digital Voltmeter with Cover Removed.

1. Allow the instrument to warm up for 30 minutes with the top and bottom covers in place.

2. Set the RANGE switch at 10V; set the SAMPLE PERIOD at 1 SEC; set the MODE switch at RUN; set the DISPLAY full clockwise (do not engage the spring-return START position).

3. Connect the input cable to the instrument and short the three input leads together. Be certain that the leads are not placed near a hot soldering iron or other heat source.

4. Remove the top cover and adjust R-1 until the readout displays all zeroes.

5. Connect the input cable leads to the standard cell bank. The red (signal high) lead is connected to the positive end of the standard cell bank; the black and blue leads are connected to the negative end of the standard cell bank. If electrical noise in the environment keeps the readout display from stabilizing, it will be necessary to connect the standard cell cabinet to the negative polarity along with the blue and black leads.

6. The readout should display the numerical value given for the standard cell bank; if it does not, adjust R-2 for agreement.

7. Reverse the polarity of the leads to the standard cell bank, taking care to avoid placing even a momentary short upon the cells. The red lead connects to negative, black and blue to positive. If necessary (as in Step 5), connect the standard cell case to one leg of the voltage source, but this time to the positive connection.

8. The readout should display the same numerical value obtained in Step 6. If the display is inaccurate, adjust R-3. This step completes the adjustment of the basic range of the instrument. Remove the standard cell bank.

9. Connect the input cable leads to the stable source of 10 (8-10V) volts through the ratio box. Record the reading. Since the instrument has already been calibrated in this range, the reading noted here is the true voltage of the stable source.

10. Using the ratio box, switch the instrument RANGE switch to provide 1 (0.8-1V) volt reading. Ignoring the decimal point, adjust R-5 so that the instrument provides the reading already recorded in Step 9.

11. Follow the procedure in Step 10, but apply 0.1 volt and set the instrument RANGE switch to 0.1V. Adjust R-4.

WARNING

The following two steps require the use of high voltage. Be careful !

12. Follow the procedure given in Step 10, but set the RANGE switch to 100 V and apply 100 volts. Adjust R-5.

13. Follow the procedure given in Step 10, but set the RANGE switch to 1000 V and apply 100 volts. Adjust R-7. This step completes the normal calibration procedure of the instrument. However, if there is a consistent and uniform error occurring in all ranges, it will be necessary to check the frequency adjustment as given in the Note preceding Step 1.

CHAPTER VI

MAINTENANCE

If a 2917A Digital Voltmeter is not working properly, or if it cannot be calibrated according to instructions, service will be required.

Before seeking out specific defective components, it is best to establish that the several power supplies are working. Specifically, voltage checks should be made at the voltage output points of the power supplies as indicated on the schematic drawings. A simple 20,000 ohm-per-volt d'Arsonval type meter may be used for these measurements. The voltage measurements should indicate correct values ±15% when read on a voltmeter with a rated accuracy of ±3%. The outputs of the regulated power supplies cannot be accurately read by this method, but in practice the accuracy of their outputs need not be known; if a regulated power supply fails, it is most likely that the voltage error will be gross (or there will be no output at all) and therefore detectable with simple measuring instruments.

If a measured voltage appears to be at an improper value, the associated power supply components should be checked; if none of these are found to be defective, it will be necessary to proceed along the defective power path, checking wiring, connectors, printed circuitry, and finally components on the boards. An obvious way to make a speedy check is to replace suspected defective boards with known good ones. Since the decade boards are all interchangeable, a malfunction affecting one decade of the readout can be made to affect other decades. For this reason, it is suggested that a trial and error approach be used and the decade boards be interchanged. If the malfunction then manifests itself in a previously unaffected decade, the defective board can be readily isolated. From this point on, a test of components will locate the precise area of failure.

It is suggested that the individual schematics be studied so as to better know what outputs may be expected at each function.

Tables 6-1 and 6-2 list specific types of malfunction. Note that any of dozens of components could fail and yet the symptom would be the same for all, there is no one component which can readily be singled out as a consistent offender. For this reason, the most useful approach to troubleshooting is to provide a list of possible types of failure and identify the plug-in board or circuit area most likely to contain the defective component.

Table 6-1. Counter Troubleshooting

In troubleshooting the instrument, the first step is to find out whether the trouble is in converter unit or in the counter unit. Once this is known, each unit can be independently repaired.

SYMPTOM	PROBABLE CAUSE	REMEDY
A. In RUN position, meter scans but gives all zero readings with inputs connected to source.	No Converter output	A-1. Connect positive voltage input of meter. A-2. Measure output pulses of photo cell at J26-10 with a 1:10 probe. Pulse height should be 50 MV, 5μ SEC., wide, minimum at 100 KC. A-3. If pulses are present with prescribed magnitude, converter is working properly. Otherwise, see troubleshooting chart for converter.
	Counter faulty	A-4. If step 3 shows converter is giving the required pulse, proceed to check pulse at P26-8. Pulse should be about 10 volt. If true, proceed to step 5. Otherwise, look for defective parts in the pulse amplifier circuit. A-5. Check for pulses at P24-5. Pulse should be steady, 5μ SEC., 10 volt with no misfirings. If good, proceed to check pulses at P26-20. Good pulses at this point show decade counter board is faulty. Proceed to step B3. Otherwise, look for defective parts in between.

SYMPTOM	PROBABLE CAUSE	REMEDY
B. Meter gives erroneous reading.	Converter gives false output.	B-1. Check the output of converter as in A-1, A-2, and A-3. If good, proceed to B-2.
	Decade boards faulty.	B-2. Check pulses at P24-5. Pulse should be 5 μSEC. 10 volts. If good, trouble is in decade boards. Proceed to B-3. Otherwise, look for defective parts in the gated one-shot. B-3. Change the decade counter boards one by one until trouble is located.
C. Meter does not scan in RUN mode; readout on all the time; input has no effect on readings.	Counter faulty.	C-1. Replace control board (P23-P24).
D. Readout does not illuminate.	Open fuse.	D-1. Replace fuse.
E. One or two decades do not illuminate.	Burnt out readout lamps.	E-1. Interchange the decade board (P11-P12) in which the unlighted lamp is located. If the same lamp still does not light, it is open. Otherwise, proceed to E-2.
	Decade board (readout buffer) faulty.	E-2. Replace decade board in question. Trouble is likely to be a defective buffer.
F. Two decimal points light at once.	Counter faulty.	F-1. Check the buffer section of buffer board (P21-P22).

SYMPTOM	PROBABLE CAUSE	REMEDY
G. Meter does not range in one or two ranges.	Range neon bulb faulty.	G-1. Rotate the RANGE control to see if the correct ranging neon bulb illuminates at each range setting. If the appropriate range light fails to illuminate, it is defective or the associated drive circuit is malfunctioning.
	Range relays faulty or photo-conductive cell faulty.	G-2. Use a jumper to short out the photo-conductive cell associated with the malfunctioning range. If jumpering will cause the range to operate, the cell is defective. If the jumper has no effect, the range relay should be suspected of malfunction.

Table 6-2. Converter Troubleshooting

Cover the photo-conductive cells in the attenuator with a strip of black tape. This will prevent external light source from actuating the range. Force the attenuator into the 10-volt range by shorting out the photo-conductive cell for the 10-volt range. Put the particular board to be checked on an extension board.

SYMPTOM	PROBABLE CAUSE	REMEDY
H. Output of amplifier stays at one voltage level; no reset pulses from resetter board.	Resetter board faulty.	H-1. Replace resetter board. Check for burned transistor or opened capacitor for the channel concerned.
J. Resetter board putting out about 120 KC pulses but amplifier output (P28-18) sits on one voltage level.	Amplifier board faulty.	J-1. Replace amplifier board.
K. Amplifier output (P28-18) produces positive and negative pulses at the same time.	Amplifier board faulty.	K-1. Remove the resetter board (P28). Apply positive voltage to the meter. Amplifier output P28-18 should swing to approximate negative, and swing to about 2 volts when input is negative. If above conditions are true, proceed to K-2. Otherwise, amplifier board is faulty.
	Resetter board faulty.	K-2. Replace the resetter board.
L. Amplifier produces only one kind of pulse, either positive or negative on P28-18.	Resetter board faulty.	L-1. Replace the resetter board. Check the NEGATIVE channel if positive pulses are produced. Check the POSITIVE channel if negative pulses are produced.

APPENDIX

SHIPPING INSTRUCTIONS

Depending upon location, the choice of carrier will vary. Never ship an instrument to us without having received shipping instructions. If requested, an estimate of charges can be made before work begins.

Be certain to pack the instrument carefully; while an outer and inner box, separated by two or three inches of excelsior is desirable, the instrument can be placed into a single container provided it is so packed that it will not shift about. As with the double box method, use two or three inches of shock-absorbent packing materials. The instrument itself should be first wrapped in heavy paper so as to keep excelsior or other particles from entering the instrument's louvres. If the original shipping container is in good condition, it may be used.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it does not operate or is damaged, a claim should be made with the carrier. The claim agent should receive a full report of damage, and this report sent to Non-Linear Systems, Inc. After receiving such a report we will advise you of the disposition of the instrument and arrange for its repair or replacement. Be certain to include model and serial number when corresponding.

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REVISIONS					
SYMB	ZONE	EFFECT	DESCRIPTION	DATE	APPD
A		4-13-65	REVISED TO INCLUDE AUTO RNG CHANGE OVERLOAD CKT.	4-8-65	

P12-13 CLOCK COUNTER OUTPUT
P12-11 "1" F.F. OUTPUT
P12-12 CLOCK COUNTER INPUT
P12-4 -10V
P12-2 +2V
P12-1 -15V
P12-9 ZERO COUNTER PULSE
P12-16 ZERO
P12-15 NOT ZERO
P12-5 UP INPUT
P12-6 DOWN INPUT
P12-14 ZERO GATE
P12-8 DOWN OUTPUT
P12-7 UP OUTPUT
P12-22 -28V
P1-3
P11-5
P11-2
P11-4
P11-1
P1-6
P12-10 READOUT BLANK
P12-3 GND.

CLOCK COUNTER

INPUT COUNTER

ZERO GATE & INVERTER

DOWN PULSE GATE

UP PULSE GATE

DENOTES READOUT → P11-13 ("0") P11-14 ("1") P11-15 ("2") P11-16 ("3") P11-17 ("4") P11-18 ("5") P11-19 ("6") P11-20 ("7") P11-21 ("8") P11-22 ("9")

DECIMAL OUTPUT

P11-8 "1" P11-9 "2" P11-10 "4" P11-11 "8"

BINARY OUTPUT

4. ALL CAPACITORS ARE IN PICO FARADS
5. ALL RESISTORS ARE ½ WATT, 10%.
6. ALL DIODES ARE 5003-002(U6315)
7. ALL TRANSISTORS ARE 2N1309.

UNLESS OTHERWISE SPECIFIED

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF	ITEM NO.	NEXT ASSY	FINAL ASSY	SHEET FINAL ASSY
PARTS LIST						APPLICATION		QTY.

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES; TOLERANCES ON DECIMALS ± .010, ANGLES ± 0° 30', FRACTIONS ± 1/32; SURFACE ROUGHNESS PER MIL-STD-10; DO NOT SCALE THIS DRAWING; RELEASE DATE 4-5-65

DRAWN H. BRIGHT 4-5-65; CHECK; APPR. Carl; MATERIAL; FINISH

NON-LINEAR SYSTEMS, INC. DEL MAR, CALIFORNIA

SCHEMATIC, DECADE BOARD WITH BI-PASS & AUTO RANGE 2923 SPECIAL

CODE IDENT NO. Q3626 SIZE E DWG. NO. 20-74

SCALE — WEIGHT —

SHEET 2 A

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REVISIONS

SYM	ZONE	EFFECT	DESCRIPTION	DATE	APPROVED

P32-10 P32-16 P32-19 P32-20 P32-21

P32-4 -10V
P32-2 +12V
P32-1 +15V

P32-8 STROBE DISABLE

STRAIN DISABLE SWITCH

RANGE COUNTER

P31-11 "05" "1"
P31-22 END of SCAN
P31-20 "05" "0"
P32-7 -29V

P32-22 Counter Reset
P32-5 Display
P31-3 START

DOWN GATE
UP GATE
AUTO RANGE BUFFER
TEST SCAN F.F.
SET STORAGE

P31-21 "0" "0"
P31-19 "0" "8"
P31-18 "0" "4"
P31-17 "0" "2"
P31-16 "0" "1"
P31-10 "0" "1"
P31-15 "1" "8"
P31-14 "1" "4"
P31-13 "1" "2"
P31-12 "1" "1"
P31-9 "1" "2"
P31-8 "1" "4"
P31-7 TO AUTO SCALER
P31-2 TEST SCAN DISABLE
P31-1
P32-12

2 CAPACITORS IN μμF
1. RESISTORS ¼W 10% CARBON

UNLESS OTHERWISE SPECIFIED

29-139 rev 2

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR CODE	CIRCUIT REF	ITEM NO	NEXT ASSY	FINAL ASSY	NEXT ASSY	FINAL ASSY
		PARTS LIST				APPLICATION		QTY	
	29-260	29-260						1	1
	29-250	29-250						1	1
	29-90	29-90						1	1

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE 2-23-65

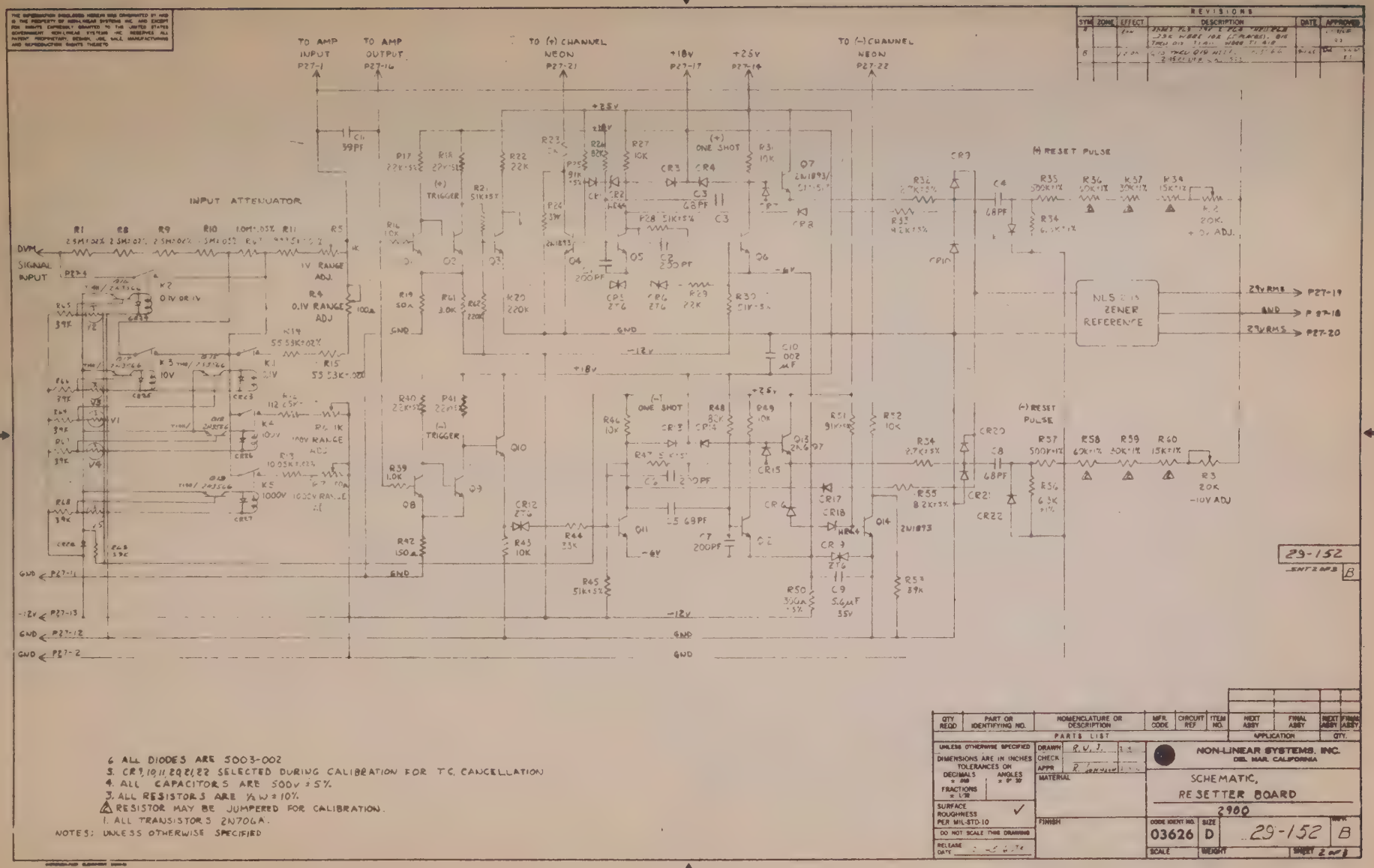
DRAWN O.J.W. 11-9-64
CHECK
APPR R.W.T. 2-19-65
MATERIAL
FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC Auto-RANGE Bd
SPECIAL 29/7 W.16 Aut. RANGE

CODE IDENT NO.	SIZE	
03626	E	29-139
SCALE	WEIGHT	SHEET 2

REV 25



REVISIONS

SYM	ZONE	EFFECT	DESCRIPTION	DATE	APPROVED
A					
B					

6 ALL DIODES ARE 5003-002
5. CR7,10,11,20,21,22 SELECTED DURING CALIBRATION FOR T.C. CANCELLATION
4. ALL CAPACITORS ARE 500V ± 5%
3. ALL RESISTORS ARE ½ W ± 10%
2. ⚠ RESISTOR MAY BE JUMPERED FOR CALIBRATION.
1. ALL TRANSISTORS 2N706A.

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR CODE	CIRCUIT REF	ITEM NO.	NEXT ASSY	FINAL ASSY	NEXT ASSY	FINAL ASSY
		PARTS LIST				APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE

DRAWN R.V.J.
CHECK
APPR
MATERIAL
FINISH

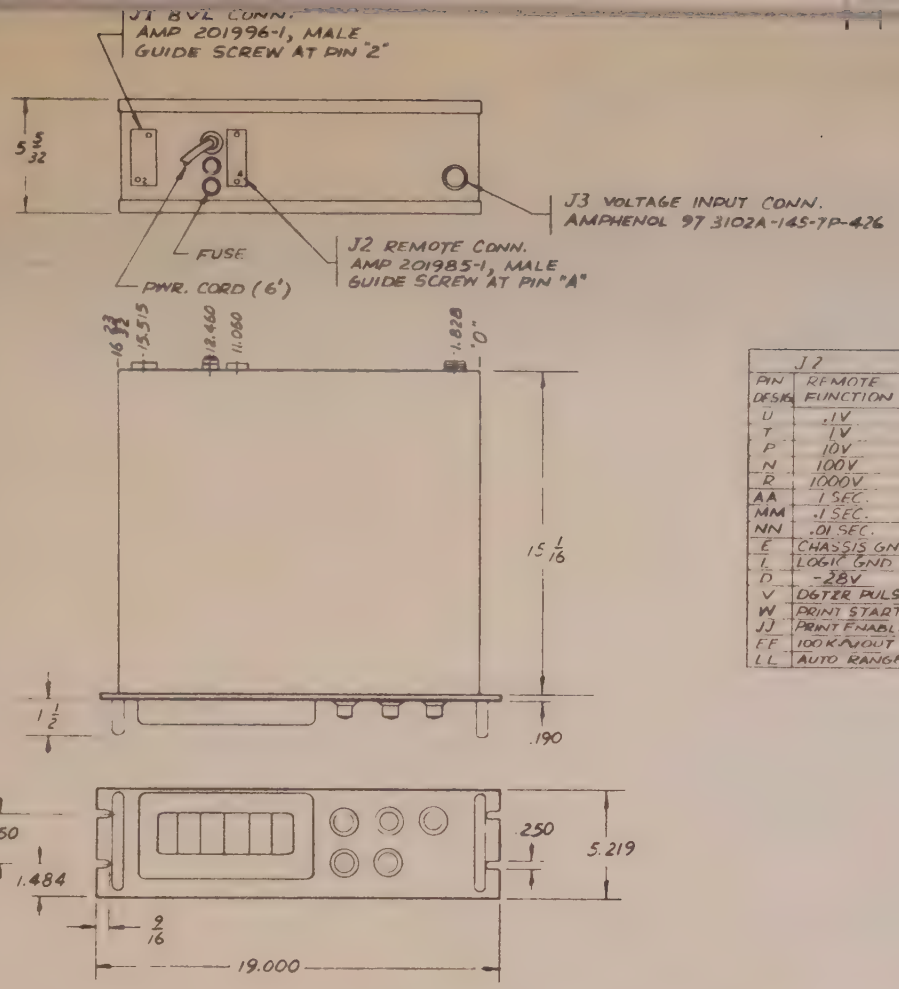
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC,
RESETTER BOARD
2900

CODE IDENT NO. 03626 | SIZE D | 29-152 | REV B
SCALE | WEIGHT | SHEET 2 OF 3

AND REPRODUCTION ... TS THERETO

J1 PIN NO.	OUTPUT FUNCTION	
25	1	FUNCTION & POLARITY
18	2	
3	4	
37	8	
70	1	10^5 DECADE (LEFT MOST)
73	2	
77	4	
80	8	
15	1	10^4 DECADE
22	2	
34	4	
58	8	
20	1	10^3 DECADE
26	2	
38	4	
63	8	
16	1	10^2 DECADE
23	2	
35	4	
59	8	
21	1	10^1 DECADE
27	2	
39	4	
64	8	
17	1	10^0 DECADE (RIGHT MOST)
24	2	
36	4	
60	8	
7	1	DECIMALS
2	2	
5	4	
1	8	
4	GND	
62	- REF.	
49	PRINT START	
12	DSTR. PULSE	
79	DVM START	
82	+ REF.	
74	PRINT ENABLE	



J2 PIN DESIG.	REMOTE FUNCTION
U	.1V
T	1V
P	10V
N	100V
R	1000V
AA	1 SEC.
MM	.1 SEC.
NN	.01 SEC.
E	CHASSIS GND.
I	LOGIC GND.
D	-28V
V	DSTR. PULSE
W	PRINT START
JJ	PRINT ENABLE
FF	100 K ANOUT
LL	AUTO RANGE

J3 PIN DESIG.	FUNCTION
A	DC IN (HI)
B	DC IN (LO)
C	GUARD SHIELD

29-178
SHT 3

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.	NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
PARTS LIST						APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32

SURFACE ROUGHNESS PER MIL-STD-10 ✓

DO NOT SCALE THIS DRAWING

RELEASE DATE 9-17-65

DRAWN H. BRINLEY 9-13-65
CHECK
APPR K.L.T 9/17/65

MATERIAL

FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

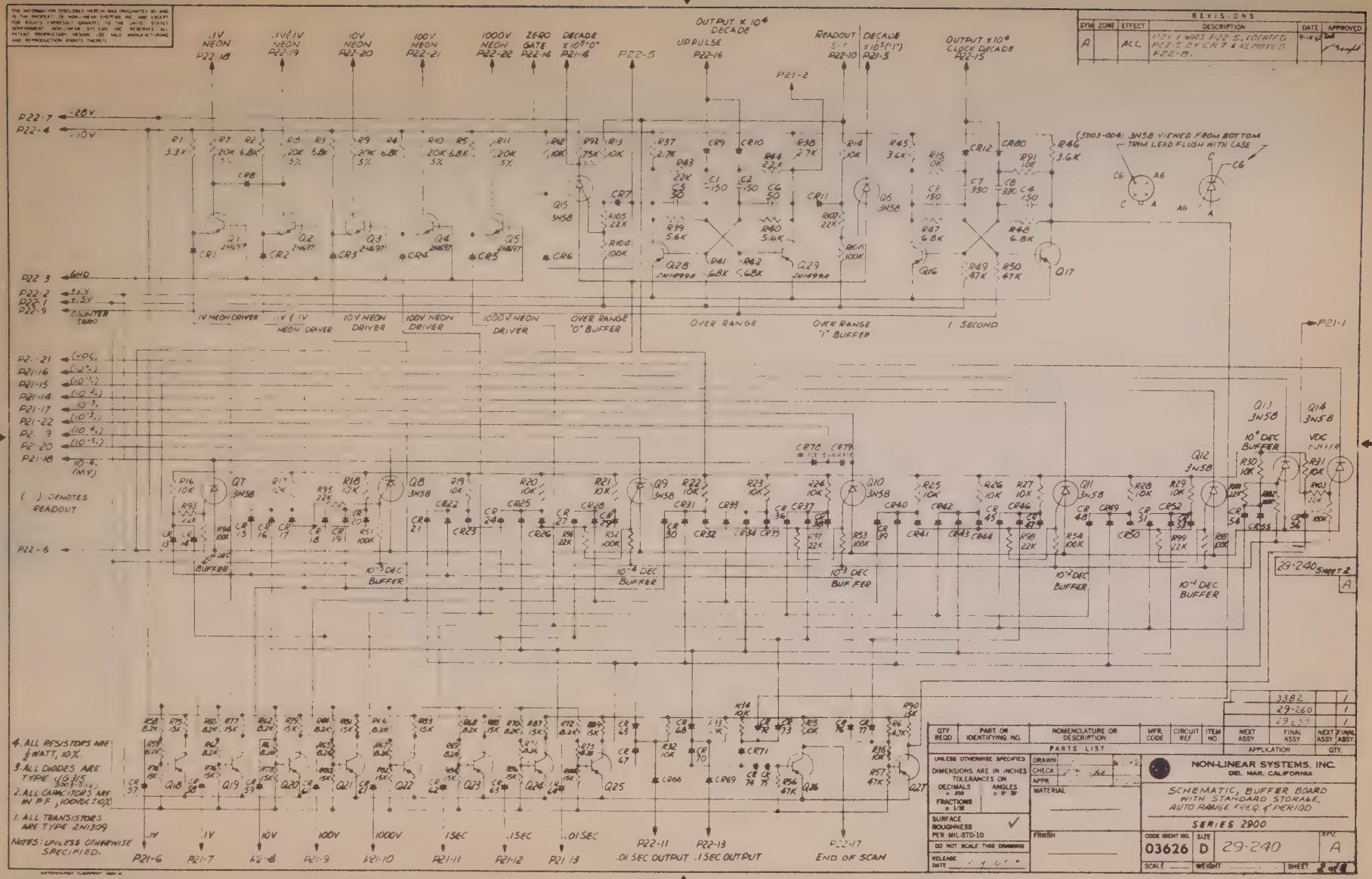
DIGITAL VOLTMETER OUTLINE DRAWING

NASA #509C024 2917A SPECIAL

CODE IDENT NO. 03626 | SIZE C | 29-178

SCALE | WEIGHT | SHEET 3

DIETERICH-POST CLEARPRINT



REVISIONS					
SYM	ZONE	EFFECT	DESCRIPTION	DATE	APPROVED
A		ALL	P21-1 WAS P22-5, LOCATED P22-5 BY CR74 & MOVED P22-8.	9-14-67	

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF	ITEM NO	NEXT ASSY	FINAL ASSY	NEXT ASST	FINAL ASST
		PARTS LIST				APPLICATION		QTY.	
						3382		1	
						29-260		1	
						29-2[illegible]		1	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ± .010 ANGLES ± 0° 30' FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE

DRAWN
CHECK
APPR.
MATERIAL
FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, BUFFER BOARD WITH STANDARD STORAGE, AUTO RANGE FREQ. & PERIOD

SERIES 2900

CODE IDENT NO. 03626 | SIZE D | 29-240 | REV. A

SCALE | WEIGHT | SHEET 2 of 2

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REVISIONS

BTR	ZONE	EFFECT	DESCRIPTION	DATE	APPROV
A		ALL			

START P23-19 · GATE P23-5 · DVM START P23-6 · TIME DELAY CONTROL P23-7 · END OF SCAN P24-18 · P24-8 · CLOCK COUNTER INPUT P24-13 · P24-15 · P24-22 · P24-19 · 100KC CLOCK P24-12 · P24-21 · DISPLAY TIME CONTROL P23-16 · P23-17 · RUN P23-15 · P23-4 · ZERO COUNTER PULSE P24-9 · BLANK READOUT P23-13 · STOP READOUT BLANKING P23-14 · READOUT BLANK P24-10

P24-7 -28V · P24-4 -10V · P24-2 +2V · P24-1 +15V · P24-20 · P24-6 DOWN · P24-5 UP · P24-14 ZERO GATE · P24-16 -PULSE · P24-17 +PULSE · P23-21 -POLARITY · P23-22 +POLARITY · P24-11 · P23-18 · P23-20 · P23-1 · P23-12

Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q21 Q22 Q23 Q24 Q25 2N2374 Q26 2N2374 Q27 ZENER Q28 9N58 5003-004 Q29 3N58 (ALT. 3N60) 5003-004 Q30 2N3640 (ALT. 2N1499A) Q31 2N3640 Q32 2N2374

SINGLE SCAN · SCAN GATE · TIME DELAY · SYNCHRONIZER · COUNTER GATE · DISPLAY TIME GENERATOR · RUN · COUNTER ZERO · END OF SCAN INVERTER · READOUT BLANK · POLARITY BUFFER · POLARITY · "0" INVERTER · UP GATE · DOWN GATE

CR1 CR2 CR3 CR4 CR5 CR6 CR7 CR8 CR9 CR10 CR11 CR12 CR13 CR14 CR15 CR16 CR17 CR18 CR19 CR20 CR21 CR22 CR23 CR24 CR25 CR26 CR27 CR28 CR29 CR30 CR31 CR32 CR33 CR34 CR35 CR36 CR37 CR38 CR39 CR40 CR41 CR42 CR43 CR44 CR45 CR46 CR47 CR48 CR49 CR50 CR51 CR52 CR53 CR54 CR55 CR56 CR57 CR58 CR59 CR60 CR61 CR62 CR63 CR64

R1 10K R2 10K R3 10K R4 10K R5 10K R6 10K R7 10K R8 10K R9 10K R10 10K R11 10K R12 10K R13 10K R14 22K R15 6.8K R16 6.8K R17 6.8K R18 6.8K R19 6.8K R20 6.8K R21 10K R22 10K R23 10K R24 10K R25 10K R26 10K R27 10K R28 10K R29 10K R30 10K R31 10K R32 10K R33 10K R34 10K R35 10K R36 10K R37 10K R38 10K R39 6.8K R40 47K R41 47K R42 47K R43 47K R44 47K R45 47K R46 47K R47 47K R48 47K R49 47K R50 47K R51 47K R52 47K R53 47K R54 47K R55 47K R56 47K R57 8.2K R58 8.2K R59 8.2K R60 8.2K R61 10K R62 100K R63 15K R64 15K R65 5K R66 47K R67 47K R68 10K R69 10K R70 3.6K R71 3.6K R72 3.6K R73 3.6K R74 3.6K R75 6.8K R76 6.8K R77 6.8K R78 6.8K R79 6.8K R80 6.8K R81 6.8K R82 6.8K R83 10K R84 6.8K R85 47K R86 47K R87 6.7K R88 10K R89 10K R90 10K R91 10K R92 200Ω R93 200Ω R94 56K R95 10K R96 47K R97 56K R98 56K R99 56K R100 56K R101 56K R102 5.6K R103 5.6K R104 22K R105 27K R106 10K R107 10K R108 22K R109 10K R110 68K R111 68K R112 56K R113 10K R114 22K

C1 .001UF C2 .001UF C3 .001UF C4 .001UF C5 .02 UF C6 .02UF C7 .001UF C8 .001 UF C9 .001UF C10 .27UF C11 .002 UF C12 1UF C13 330 PF C14 330PF C15 150 PF C16 150 PF C17 50PF C18 50PF C19 330PF C20 .1UF C21 .01UF

5003-004

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL TRANSISTORS ARE TYPE 2N1309.
2. ALL DIODES ARE TYPE US315(5003-002).
3. ALL RESISTORS ARE ¼W, 10%
4. ALL CAPACITORS ARE 100V, 20%.
5. R16 REF DESIGNATION NOT USED

QTY. REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SPEC. CODE	CIRCUIT REF	ITEM NO.	NEXT ASSY	FINAL ASSY.	NEXT ASSY	FINAL ASSY
		PARTS LIST				APPLICATION		QTY.	
						3382			/
						4260			/
						29-250			/

UNLESS OTHERWISE SPECIFIED · DIMENSIONS ARE IN INCHES · TOLERANCES ON DECIMALS .XX ± .01, .XXX ± .005, ANGLES ± 0° 30', FRACTIONS ± 1/32 · SURFACE ROUGHNESS PER MIL-STD-10 ✓ · DO NOT SCALE THIS DRAWING · RELEASE DATE 8-3-65(2) · DRAWN · CHECK · APPR · MATERIAL · FINISH

NON-LINEAR SYSTEMS, INC. OCEANSIDE, CALIFORNIA

SCHEMATIC, VITRAL BOARD WITH STROBE, BLT. BLANK FREQ SYN.

SERIES 2900

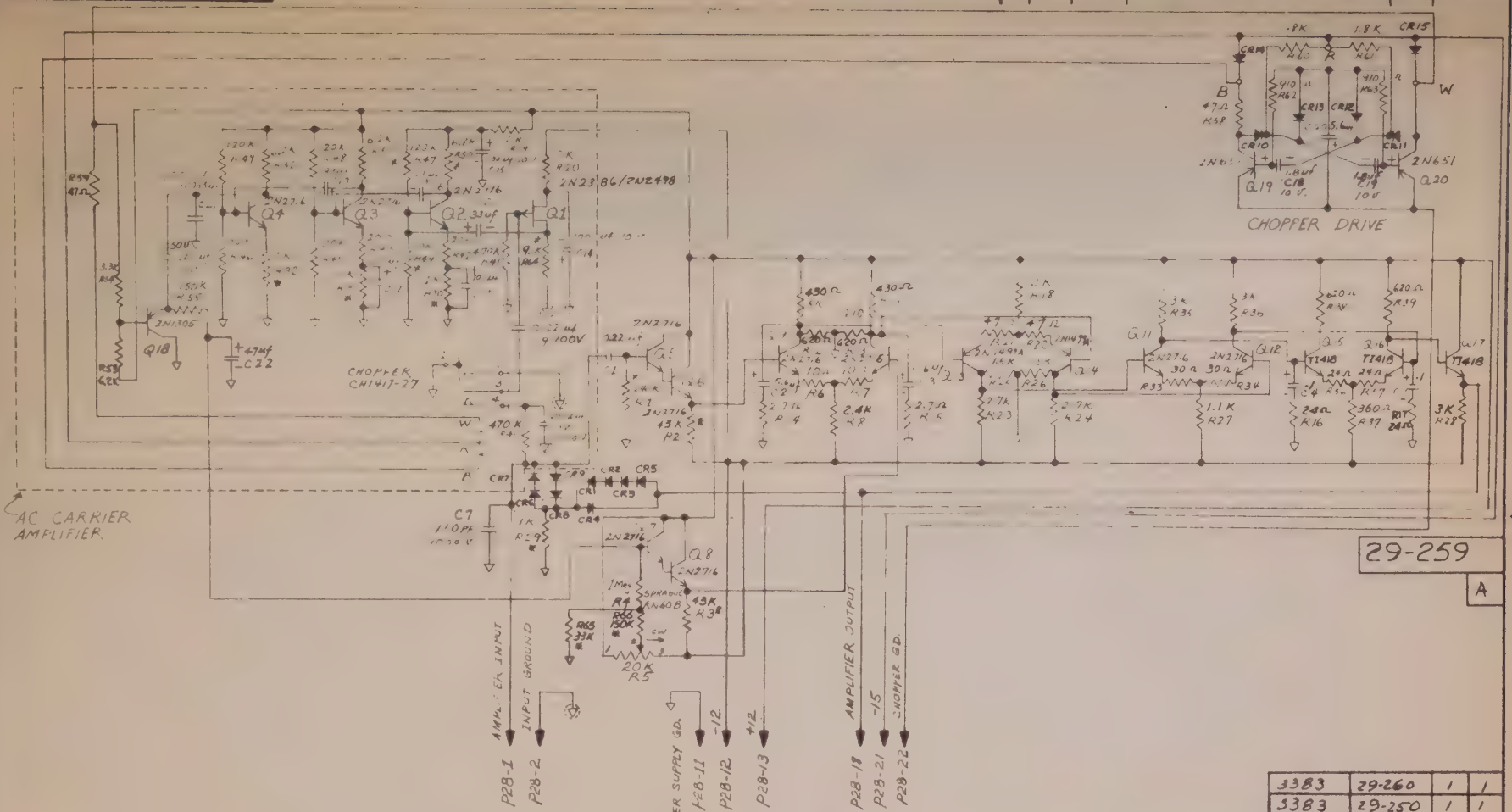
CODE IDENT NO.	SIZE	DWG NO.	REV
03626	E	29-253	A

SCALE — · WEIGHT — · SHEET 2 of 3

29-253 SHT 2 A

GOVERNMENT, ... LINEAR SYSTEMS INC. RESERVES ALL PATENT, PROPRIETARY, DESIGN, USE, SALE, MANUFACTURING AND REPRODUCTION RIGHTS THERETO.

A		ALL	CHANGED 2N3635 TO 2N3565. ADDED ALT. FOR Q1, INCORP E.O. #1	9-7-65	RJ



29-259

A

3383	29-260	1	1
3383	29-250	1	1
3383	3382	1	1

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.	NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
		PARTS LIST				APPLICATION		QTY.	

4. 2N3565 IS AN ALTERNATE FOR 2N2716 (Q2 THRU Q12), 2N3565 IS AN ALTERNATE FOR T1418 (Q15, 16 & 17).
3. C1, C4 & C5 ARE 100 VOLTS, C2, C3, C12, C13 & C20 ARE 10 VOLTS, C16 & C17 ARE 3 VOLTS.
2. ALL RESISTORS ARE ½ WATT, 5 %, AB EXCEPT THOSE MARKED WITH ASTERISK (*) ARE CORNING C-20.
1. DIODES D6 THRU D9 ARE 1N458, ALL OTHERS ARE TYPE UG-315 (5003-002).

NOTES: UNLESS OTHERWISE SPECIFIED:

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32

SURFACE ROUGHNESS PER MIL-STD-10 ✓

DO NOT SCALE THIS DRAWING

RELEASE DATE 8-4-65

DRAWN Hanrahan 7-7-65
CHECK Knight
APPR RWJ 7-8-65

MATERIAL

FINISH

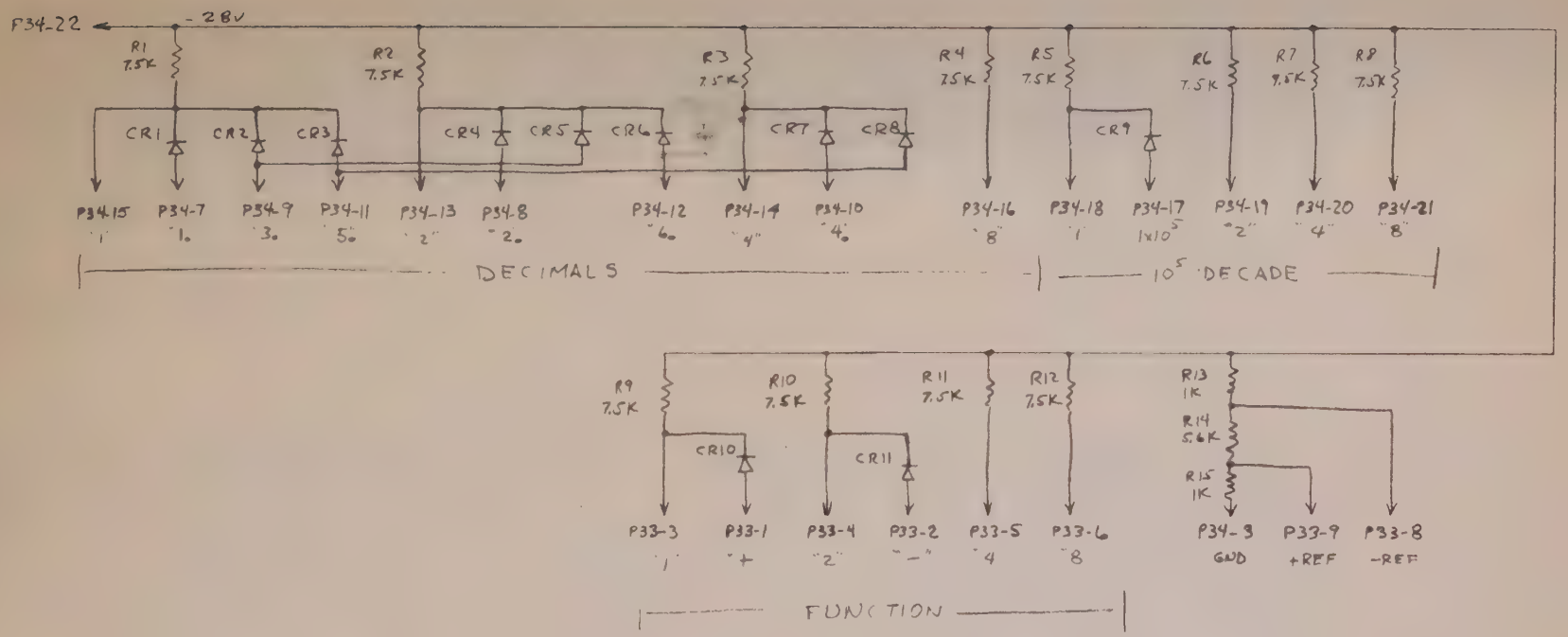
NLS NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, AMPLIFIER BOARD —

SERIES 2900 - MODEL 2917A

CODE IDENT NO. 03626 | SIZE C | 29-259 | REV. A

SCALE ____ | WEIGHT ____ | SHEET 2 of 3



QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED		CONTR. NO.	
DIMENSIONS ARE IN INCHES TOLERANCES ON		DRAWN	9-7-65
DECIMALS ± .010	ANGLES ± 0° 30'	CHECK	
FRACTIONS ± 1/32		APPR	9-17-65
		RELEASE DATE	9/17/65

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC,
8421 CODE BOARD

NASA-509C024

SIZE	CODE IDENT NO.	
C	03626	29-302

SCALE	WEIGHT	SHEET 2 of 3

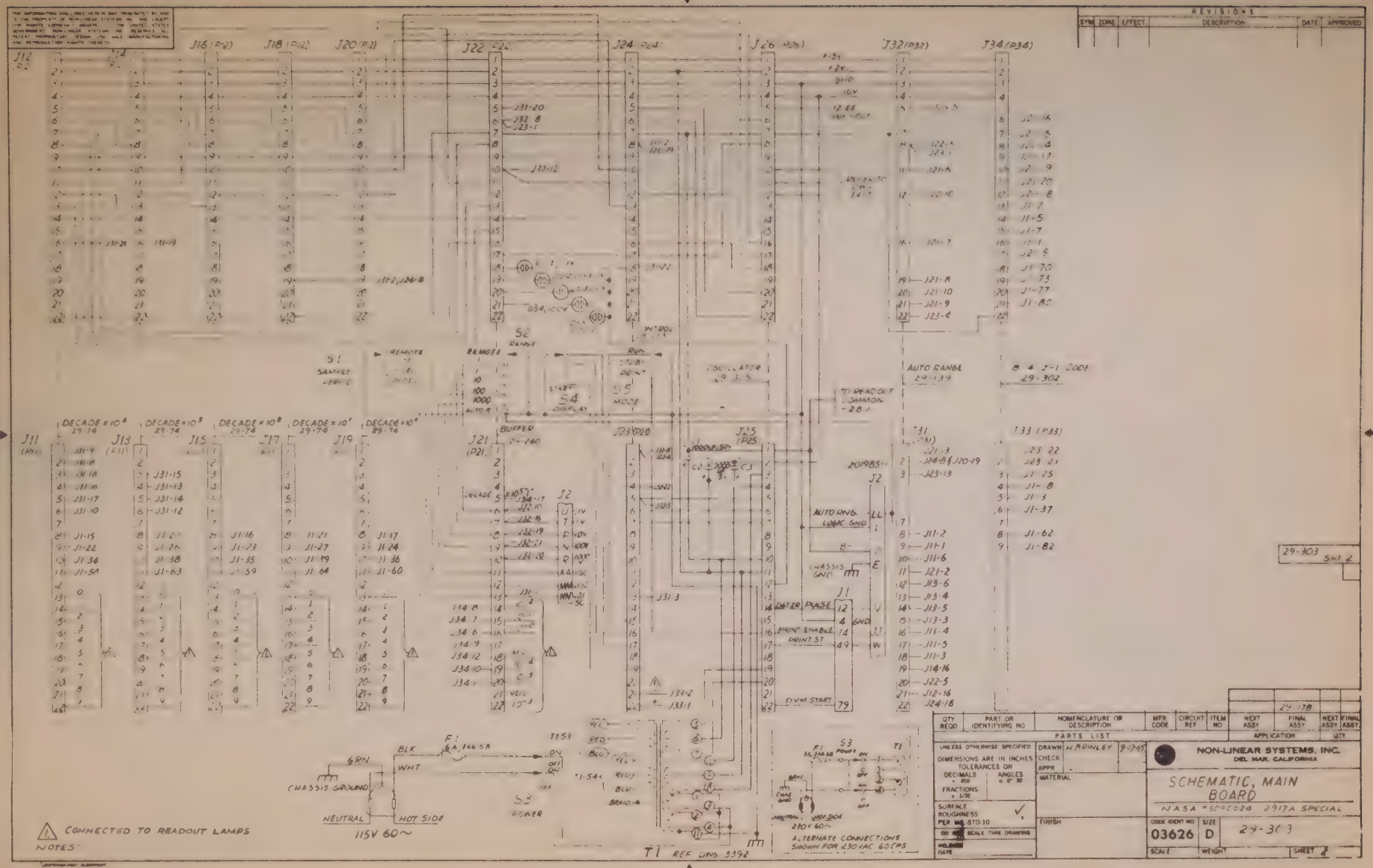
MATERIAL

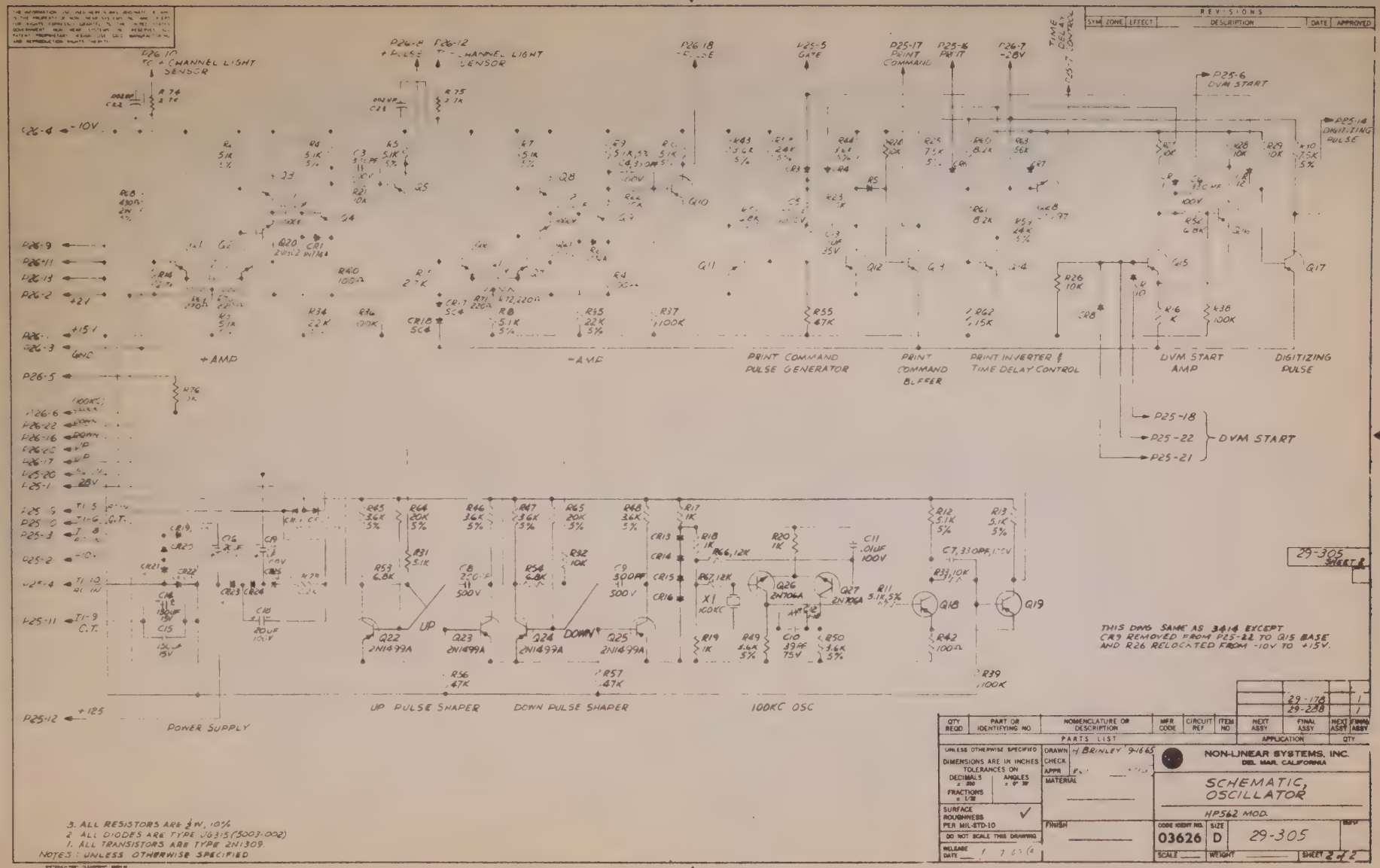
			29-206
			29-176
NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
APPLICATION		QTY.	

NOTES:

1. ALL DIODES 5003-002

29-302 SHT 2


REVISIONS
SYM ZONE EFFECT DESCRIPTION DATE APPROVED
J12 (P12)
J16 (P16)
J18 (P18)
J20 (P20)
J22 (P22)
J24 (P24)
J26 (P26)
J32 (P32)
J34 (P34)
S1 SAMPLE RATE
S2 RANGE
S3 POWER
S4 DISPLAY
S5 MODE
REMOTE
AUTO RANGE
OSCILLATOR
BUFFER
DECADE ×10⁴
DECADE ×10³
DECADE ×10²
DECADE ×10¹
DECADE ×10⁰
J11 (P11)
J13 (P13)
J15 (P15)
J17 (P17)
J19 (P19)
J21 (P21)
J23 (P23)
J25 (P25)
J31 (P31)
J33 (P33)
J1
J2
AUTO RNG. LOGIC GND
CHASSIS GND
PRINT ENABLE
PRINT ST
DVM START
TO READOUT COMMON -28V
F1 .25A 250V SB
T1 REF DWG 3392
115V 60~
230V 60~
ALTERNATE CONNECTIONS SHOWN FOR 230VAC 60CPS
CHASSIS GROUND
NEUTRAL
HOT SIDE
GRN
BLK
WHT
CONNECTED TO READOUT LAMPS
NOTES:
29-303 SH 2
29-178
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA
SCHEMATIC, MAIN BOARD
NASA "SC" 0024 2917A SPECIAL
03626 D 29-303
SCALE WEIGHT SHEET 2
PARTS LIST
QTY REQD | PART OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION | MFR CODE | CIRCUIT REF | ITEM NO | NEXT ASSY | FINAL ASSY | NEXT ASSY | FINAL ASSY
APPLICATION QTY
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ANGLES
FRACTIONS
SURFACE ROUGHNESS PER MIL-STD-10
DO NOT SCALE THIS DRAWING
DRAWN H. PRINLEY 9-7-65
CHECK
APPR
MATERIAL
FINISH



THIS DWG SAME AS 3414 EXCEPT CR9 REMOVED FROM P25-22 TO Q15 BASE AND R26 RELOCATED FROM -10V TO +15V.

29-305 SHEET 2

NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL TRANSISTORS ARE TYPE 2N1309.
2. ALL DIODES ARE TYPE UG315(5003-002)
3. ALL RESISTORS ARE ½W, 10%

REVISIONS					
SYM	ZONE	EFFECT	DESCRIPTION	DATE	APPROVED

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR CODE	CIRCUIT REF	ITEM NO	NEXT ASSY	FINAL ASSY	NEXT ASSY	FINAL ASSY
PARTS LIST						APPLICATION		QTY	
						29-178		1	
						29-228		1	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE 1 7 65

DRAWN H BRINLEY 9-1665
CHECK
APPR
MATERIAL
FINISH

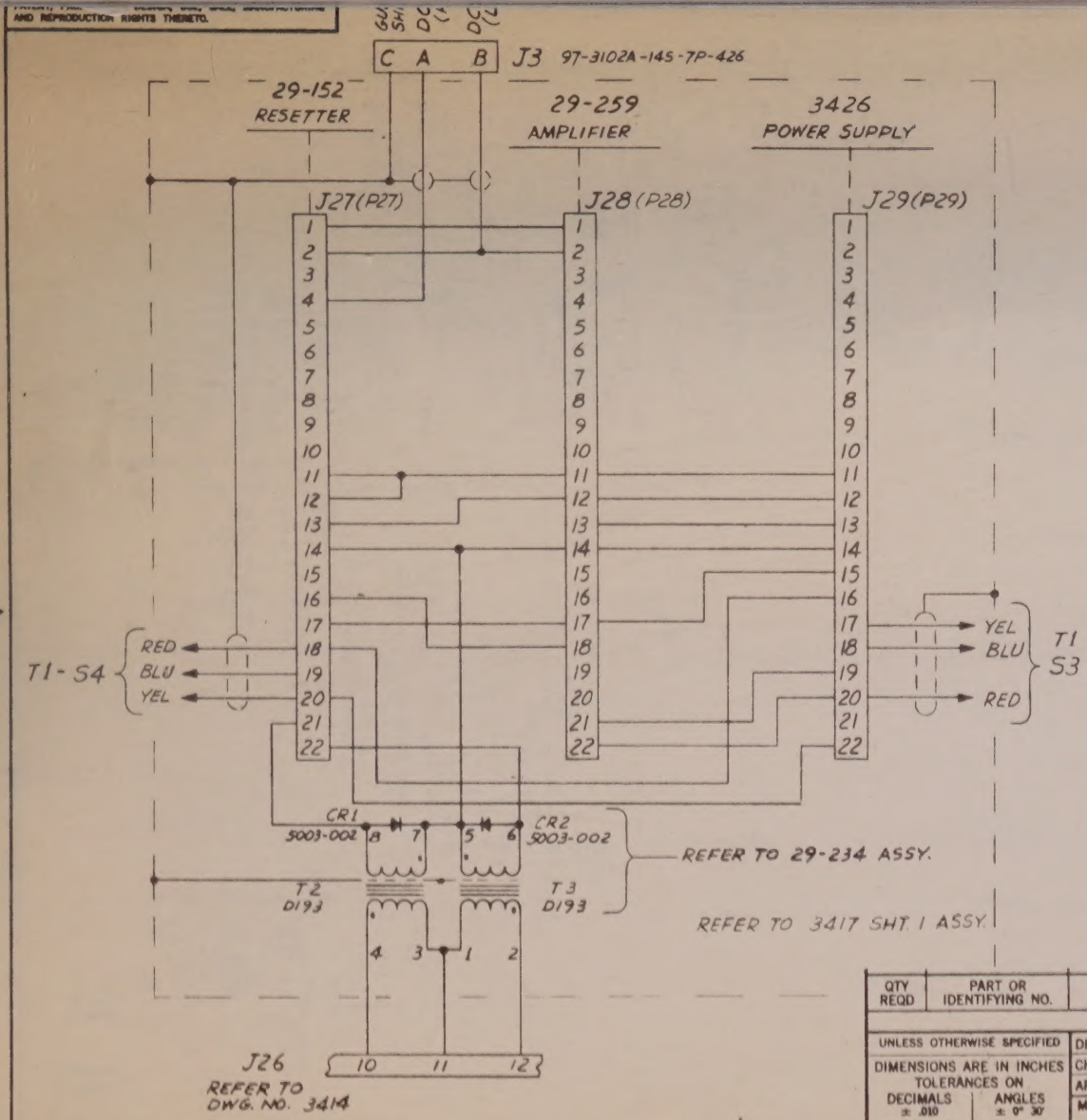
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, OSCILLATOR
HP562 MOD.

CODE IDENT NO. 03626 | SIZE D | 29-305 | REV
SCALE | WEIGHT | SHEET 2 of 2

AND REPRODUCTION RIGHTS THERETO.

C			J28-3, J3-B WAS TO J27 & J28-3.	7-27-65	
B			REMOVED DS1 & DS2 LAMPS. ADDED 29-234 ASSY. SCHEMATIC. 29-152 WAS 3420 & 29-259 WAS 3423	7-9-65 HAB	230-65 KWJ
C			J26-11 WAS J26-13	9-16-65 HAB	9-16-65 KWJ



3417 SHT. 2

C

3383	29-260	1	1						
3383	29-250	1	1						
3383	3382	1	1						
QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.	NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
PARTS LIST						APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE Rev A & B released 8-4-65

DRAWN H. BRINLEY 7-10-64
CHECK
APPR R. JOHNSON 7-15-64
MATERIAL
FINISH

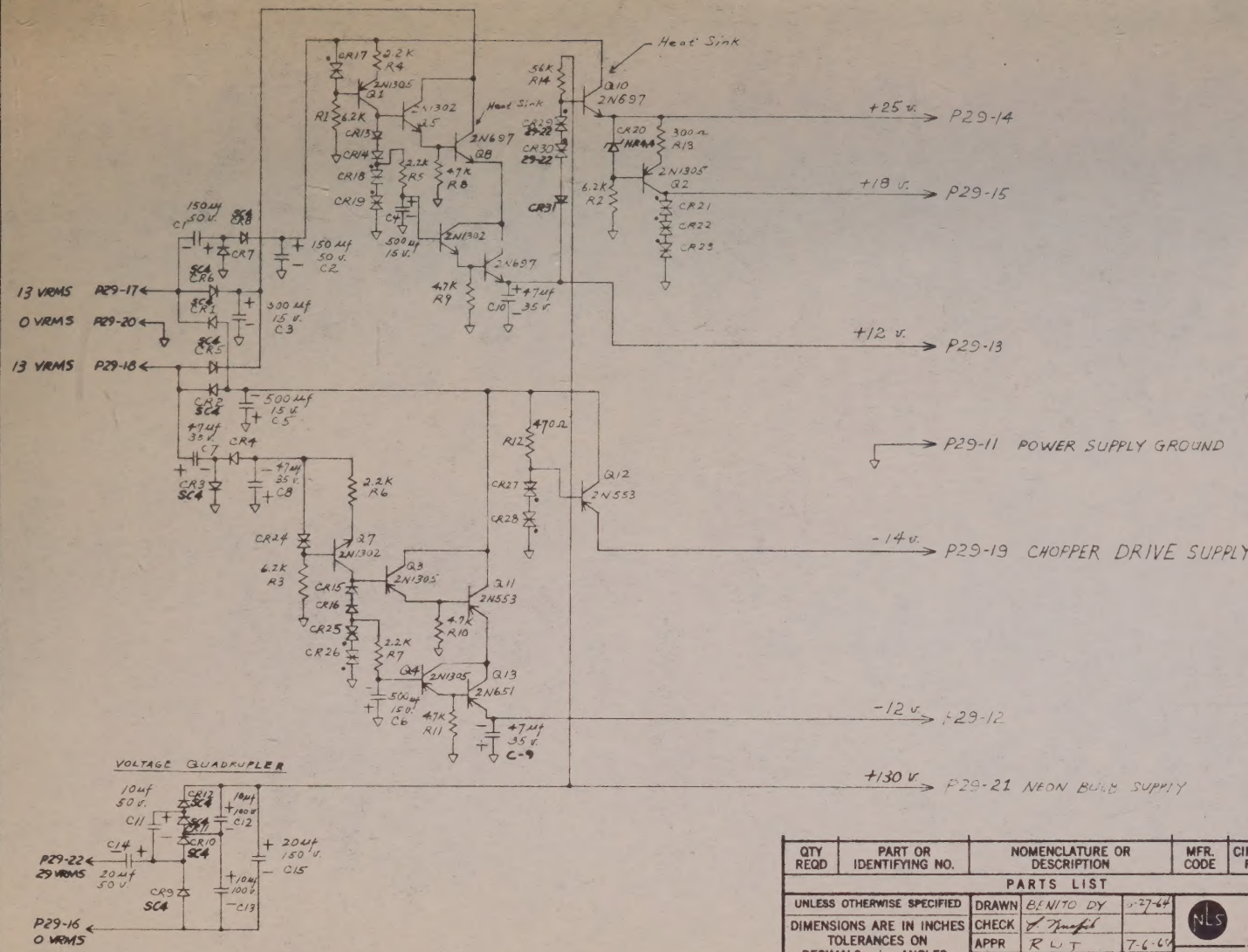
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, INTERCONNECTING BOARD

2900

CODE IDENT NO. 03626 | SIZE C | 3417

SCALE | WEIGHT | SHEET 2



3426 SHEET 2

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.	NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
						3383	29-260	1	1
						3383	29-250	1	1
						3383	3382	1	1
		PARTS LIST				APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE 4-5-65(2)

DRAWN BENITO DY 3-27-64
CHECK [illegible]
APPR R L T 7-6-64
MATERIAL
FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC
POWER SUPPLY BOARD
2900

CODE IDENT NO. 03626 | SIZE C | 3426
SCALE | WEIGHT | SHEET 2 of 3

1. ALL RESISTORS ARE ½ WATT, 10%
2. ALL ZENER DIODES ARE RT-6.
3. ALL DIODES ARE 5003-002 (UG-315)
4. ALTERNATE DIODE FOR SC-4 IS IN5003.

NOTES: UNLESS OTHERWISE SPECIFIED

non linear
systems, inc.

DEL MAR, CALIFORNIA

MP MASTER

MA33783